Impact of Technological Change on Foreign Trade: Comparative Analysis of the St. Lawrence Seaway and the Panama Canal

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Two modern canals that have been especially important to waterborne commerce of the United States are the Panama Canal and the St. Lawrence Seaway. The Panama Canal, opened in 1914, connects the Pacific and Atlantic Oceans via the narrow isthmus of Panama, saving thousands of miles of travel around South America. The St. Lawrence Seaway, opened in 1959, connects the inland Great Lakes of the United States and Canada with the Atlantic Ocean via the St. Lawrence River. Both of these waterways are considered vital arteries of commerce for U.S. foreign trade. But today, evolving shipping technologies on both land and sea and changes in world trade patterns raise questions about the long-term role of both waterways. The Panama Canal consists of six double-chambered locks with dimensions of 110 by 1,000 ft and a controlling depth of 41.5 ft. The St. Lawrence Seaway consists of seven locks 80 by 860 ft and a controlling depth of 27 ft. The lock dimensions, in turn, affect the maximum vessel sizes able to transit each waterway. These limiting dimensions are becoming an increasingly important factor in the role each waterway plays in world trade. Although a trend toward larger vessel sizes has been common throughout the history of world trade, the rapid increase in the size of vessels in the post-war period has been especially dramatic. Traffic trends are revealing: Panama Canal traffic peaked in 1982 and then declined precipitously with the recession, a decline in grain traffic, and the opening of a trans-isthmus pipeline. Traffic recovered slowly through 1988, but declined again in 1989. The advent of rail "minibridge"—the movement of Far East imports in double-stack container trains from the U.S. West Coast to markets in the Midwest and East—has siphoned off high-value traffic that would otherwise have moved via the Panama Canal. The introduction in the Pacific trade of "post-Panamax" containerships that are too wide to transit the canal further entrenches the minibridge alternative. As the double-stack network in the United States matures, greater westbound movements off the Atlantic seaboard seem inevitable. In the bulk trades, particularly coal, deepening at U.S. ports favors the use of larger ships that are also unable to transit the canal. Similarly, traffic on the St. Lawrence Seaway peaked in 1979 and has been largely flat or in decline in the years since. Grain exports are being shipped more economically via the Mississippi River and Gulf ports or via West Coast ports, and container traffic is virtually nonexistent. As the average vessel size in the world fleet continues to grow, the percentage of the fleet able to transit each waterway continues to decline. Enlarging either system to handle larger ships would be a very expensive undertaking and would also raise a host of environmental issues, so ultimately both waterways seem likely to play a diminished role in world trade.

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Throughout history waterways have been used to facilitate trade and reduce the cost of transporting cargo from here to there. Rivers were deepened and widened to allow safe passage of boats for passengers and cargo. Canals were dug around rapids or to connect other bodies of water. Two modern canals that have been especially important to waterborne commerce of the United States are the Panama Canal and the St. Lawrence Seaway. The Panama Canal connects the Pacific Ocean with the Caribbean Sea and the Atlantic Ocean across the narrow isthmus of Panama, saving thousands of miles of travel around South America. The St. Lawrence Seaway connects the inland Great Lakes of the United States and Canada with the Atlantic Ocean via the St. Lawrence River. Major characteristics of both of these contemporary waterways will be examined in this paper, including their origins, traffic patterns, physical dimensions, and the implications of evolving vessel technologies on the role of each waterway in future world trade.

Topics	*Panama Canal*	*St. Lawrence Seaway*
5 Ws	✓	✓
Traffic	✓	✓
Revenue	✓	✓
Lock size	✓	✓
Ship size	✓	✓
Technology impacts	✓	✓
Outlook	✓	✓

HISTORY AND CHARACTERISTICS

Both of these canal systems were envisioned for hundreds of years, but actual construction and operation did not take place until this century as follows:

		Panama Canal	*St. Lawrence Seaway*
When:	Authorization	1902	1954
	Construction	1904–1914	1955–1958
	Open	1914	1959

The Panama Canal took over 10 years to build, and opened for shipping in August 1914 (*1*). The St. Lawrence Seaway was built in joint cooperation between the United States and Canada over a four-year period and opened to deep draft traffic in 1959 (*2*).

The United States, under treaty with Panama, undertook the construction of the Panama Canal for a number of reasons, including military and strategic, trade between the east and west coasts of the United States, and the facilitation of world trade, as follows:

	Panama Canal	*St. Lawrence Seaway*
Why:	U.S. Navy U.S.-U.S. trade World trade	Labrador iron ore to United States Grain exports World trade
Who:	United States and treaty with Panama	Canada (72%) and United States (28%)

The St. Lawrence, on the other hand, was built jointly by Canada and the United States, with the former sharing the much larger ownership stake (72 percent versus 28 percent for the United States). Connecting the Great Lakes and the Gulf of St. Lawrence with a waterway that could handle oceangoing ships facilitated both the movement of Labrador iron ore to Great Lakes steel mills and the export of Canadian and U.S. grain, and it opened up the midcontinent market to world seagoing trade.

The Panama Canal has six double-chamber locks with dimensions of 110 by 1,000 ft and a controlling depth of 41.5 feet. The St. Lawrence Seaway consists of seven locks 80 by 860 feet and a controlling depth of 27 ft. The Seaway lock size was designed to be consistent with the eight Welland Canal locks built by Canada during the 1930s to connect Lake Ontario and Lake Erie. The lock dimensions, in turn, affect the maximum vessel sizes able to transit each waterway. On the Panama Canal, the maximum vessel size is 106 by 950 ft, and a loaded draft of about 40 ft. On the St. Lawrence, vessels may be no longer than 76 by 730 ft and draw 26 ft of water.

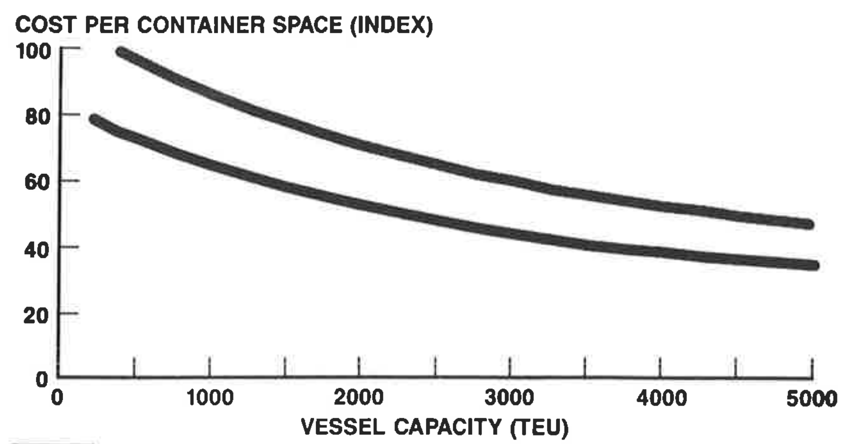
These limiting vessel dimensions are becoming an increasingly important factor in the role each waterway plays in world trade. Although a trend toward larger vessel sizes has been common throughout the history of world trade, the rapid increase in the size of vessels in the post-war period has been especially dramatic. Between 1947 and 1968, the number of ships in the world fleet increased by about 50 percent. However, the cargo capacity of the world fleet increased by about 200 percent during this period, suggesting a remarkable increase in average vessel size (*3*). This growth in average ship size is based on the economics of transport. As the draft (and overall size) of a dry bulk vessel or tanker increases, more cargo can be loaded per vessel and the cost per ton-mile falls. Of course, a similar relationship holds for containerships and other commercial vessels. As the vessel capacity in Twenty-foot Equivalent Unit containers (TEUs) increases, the relative cost of per container space diminishes (Figure 1).

PANAMA CANAL TRAFFIC

Looking at fluctuations in Panama Canal traffic over time will help put some of these changes in vessel technology into perspective. The canal stretches for more than 50 mi between the Pacific and the Caribbean (Figure 2). Vessels "step up" via the locks to freshwater Gatun Lake, 85 ft above sea level, which provides water to operate the system. Channel widths through the canal vary from 500 to 1,000 ft. The average transit time is 8 to 10 hr.

Total traffic through the canal peaked in 1982 at over 185 million long tons (Figure 3). Tanker and dry bulk vessels dominated. Tonnage declined precipitously in 1983 with the opening of the trans-Panama oil pipeline and the recession in world shipping (*4*). Tanker volume fell by half, and dry bulk volume had moderate declines through 1986. Total traffic showed no real rebound until 1987, when dry bulk volumes recovered to 1983 levels. Container traffic has generally posted small increases in tonnage each year. In looking at volume of traffic by direction, impact of the 1983 pipeline opening on tankers is even more dramatic (Figure 4). Pacific to Atlantic tanker traffic fell by nearly two-thirds in that year. It was squeezed even more in 1987 by changing patterns associated with the fall in oil prices. For Atlantic to Pacific traffic, the recession had more impact, especially on the bulk trades (Figure 5). Recovery began in 1987, when sharply higher bulk tonnage pushed total traffic to over 87 million tons.

A look at traffic by commodity also shows the dominance of the liquid and dry bulk trades. For total traffic, petroleum and products dominated until the opening of the pipeline, but



SOURCE: BASED ON C.R. CUSHING, 1984.

FIGURE 1 Relationship of container-carrying capacity to cost-container.

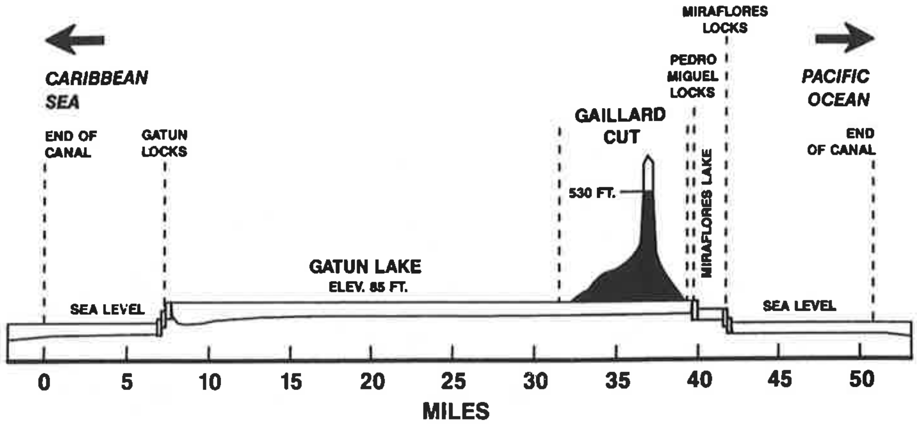
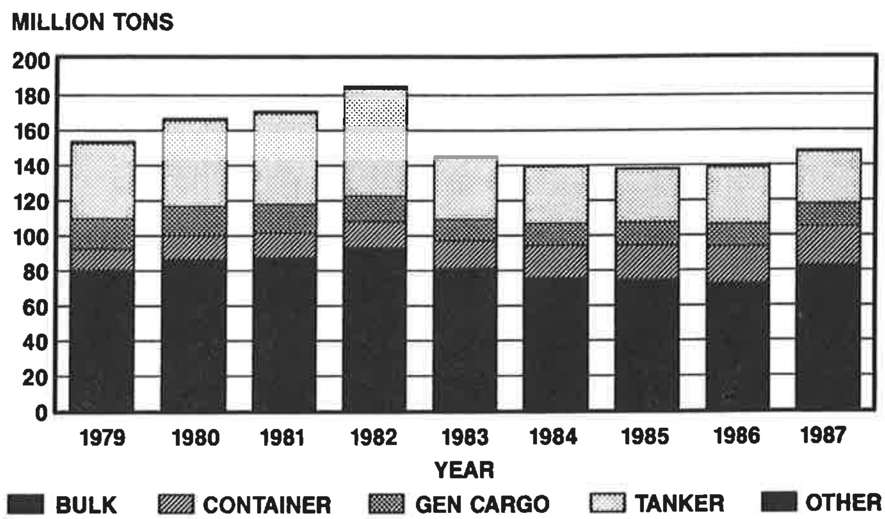


FIGURE 2 Longitudinal profile of Panama Canal (vertical exaggeration 80 times).



Source: Panama Canal Commission, Annual Report.

FIGURE 3 Panama Canal traffic by vessel type: total for both directions.

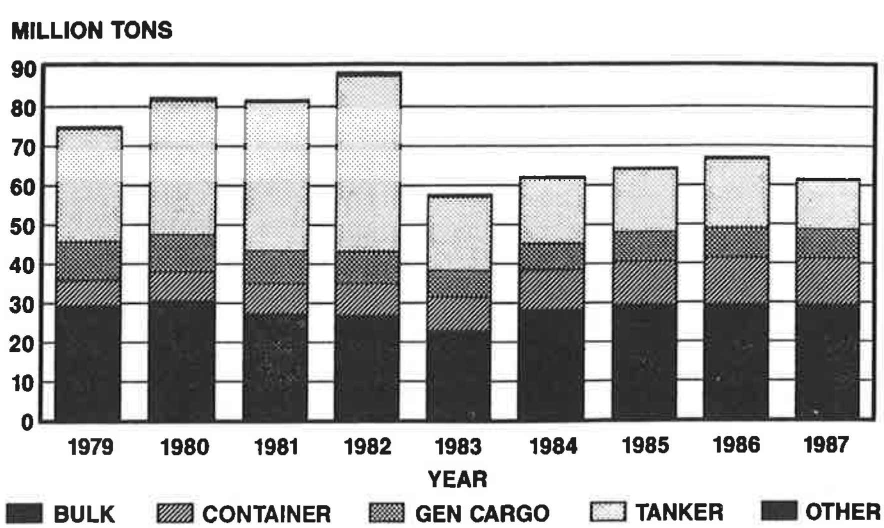
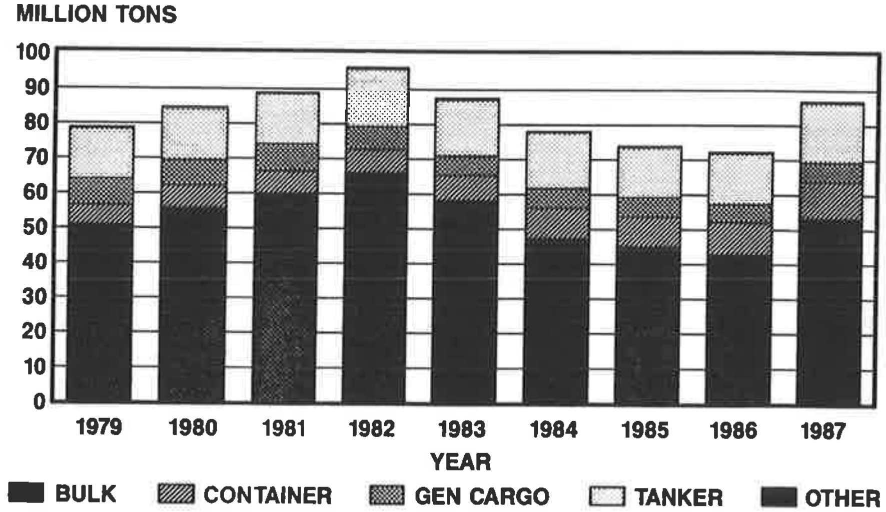


FIGURE 4 Panama Canal traffic by vessel type: Pacific to Atlantic.



Source: Panama Canal Commission, Annual Report.

FIGURE 5 Panama Canal traffic by vessel type: Atlantic to Pacific.

farm products were an important second and coal was growing steadily (Figure 6). With the recession and the oil pipeline opening, coal and petroleum fell markedly. Farm products traffic began declining in 1984. Recovery in 1987 was due to growth in farm products, forest products, and fertilizers and other minerals. Coal and petroleum continue to be weak. By direction, Pacific to Atlantic traffic in petroleum of course plunged in 1983, but there was also weakness in other commodities (metallic ores, farm products) that has persisted to the present time (Figure 7). Growth has been notable only for forest products and fertilizer and other minerals. For Atlantic to Pacific traffic, the fall in coal after 1982 and farm products after 1983 is most prominent (Figure 8). Farm products traffic recovered notably in 1987, and fertilizer and other minerals also showed growth.

Container Trade

Unlike the bulk trades, container traffic through the Panama Canal has generally continued to grow each year, led by rapidly increasing demand for containerized imports to the United States. For example, the growth in containerized imports from Pacific Rim nations to the U.S. more than doubled from 1.3 million TEUs in 1982 to nearly 2.8 million TEUs by the end of 1987 (*5*).

Like the bulk trades, however, containerships have been characterized by continued growth in vessel dimensions. This has culminated in the development of the "post Panamax" container vessel (Figure 9) (Speech by Brig. Gen. Patrick J. Kelly, USACE, on "West Coast Ports and Future Trends" at meeting of Panama Canal Commission, January 1988).

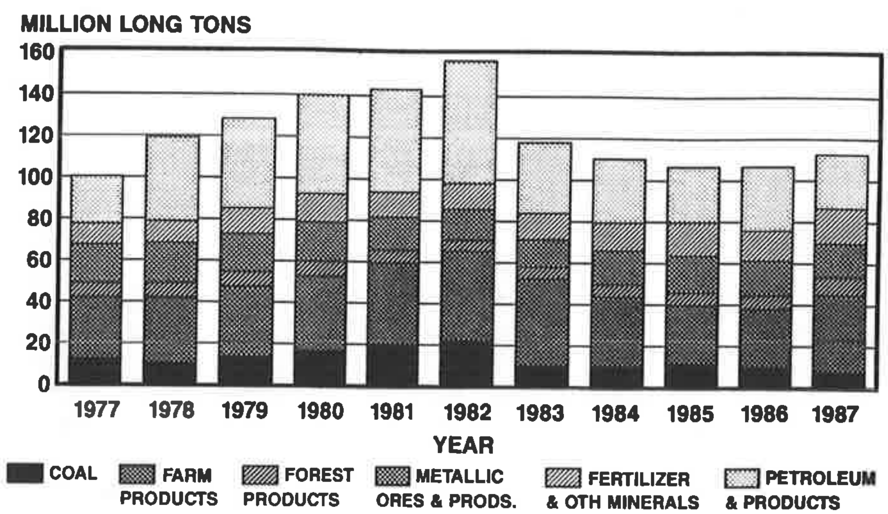
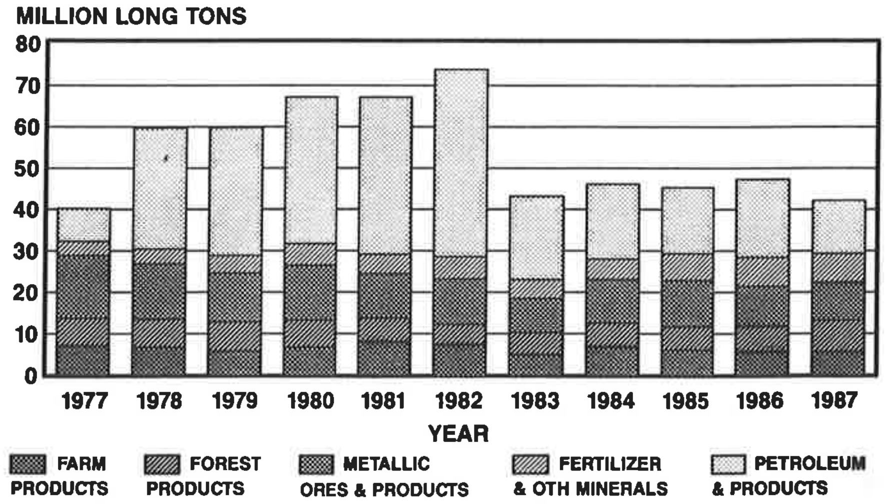
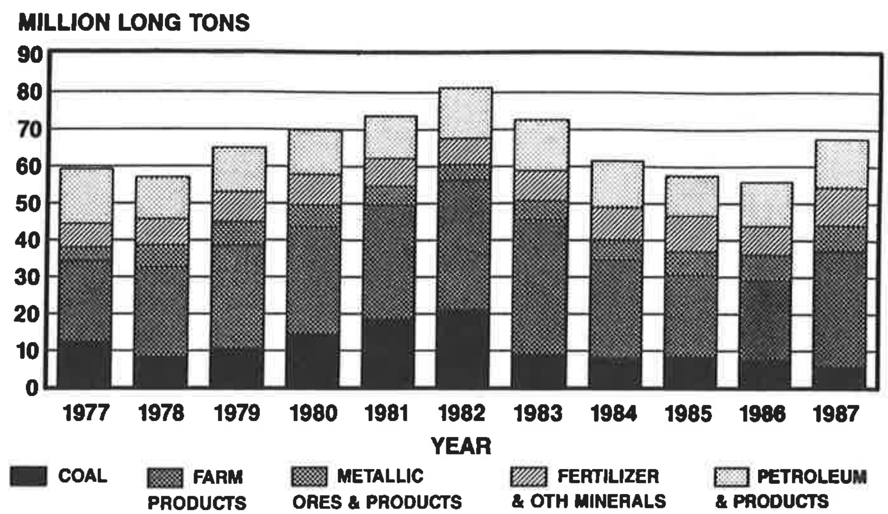


FIGURE 6 Panama Canal traffic: major commodities, both directions.



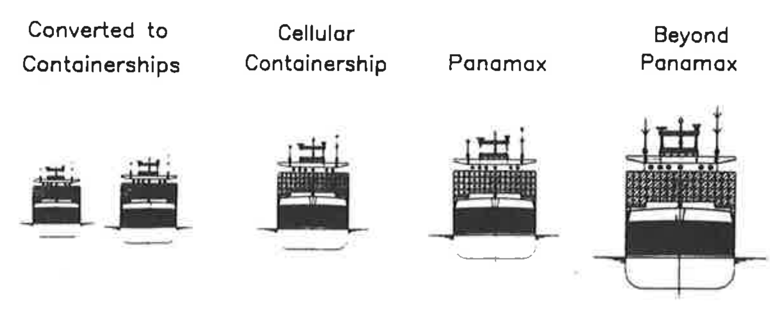
Source: Panama Canal Commission, Annual Report.

FIGURE 7 **Panama Canal traffic: major commodities, Pacific to Atlantic.**



Source: Panama Canal Commission, Annual Report.

FIGURE 8 **Panama Canal traffic: major commodities, Atlantic to Pacific.**



Beam	76'	90'	90'	105'	135'
Draft	< 30'	30'	33'	38'	38'
TEUs	<1000	1000	2000	3000	4–5000

FIGURE 9 **Containership evolution: beam size and draft.**

Early containerships were modified general cargo ships with a beam of about 76–90 ft. Subsequently, fully cellular containerships were built with about double the TEU capacity of earlier ships. Panamax-sized vessels followed with a beam of about 105 ft and about a third more TEU capacity than the earlier cellular containerships. This was the largest practical vessel beam that would still permit transit of the Canal. In 1988, American President Line (APL) took delivery of five new "C10" ships with a beam of 129 ft, making them the first containerships too wide to transit the Panama Canal (*6*). APL has committed to a strategy of relying on rail minibridge to move Far East imports from West Coast ports to markets in the eastern United States, bypassing the canal. That this APL strategy is paying off is shown by the carrier's dominance of containerized imports entering the Eastern seaboard from Asia (*7*).

The challenge to the Panama Canal from such minibridge movements can be seen graphically in Figures 10 and 11. Containerized imports from the Far East destined for markets in the eastern United States can move via the Panama Canal

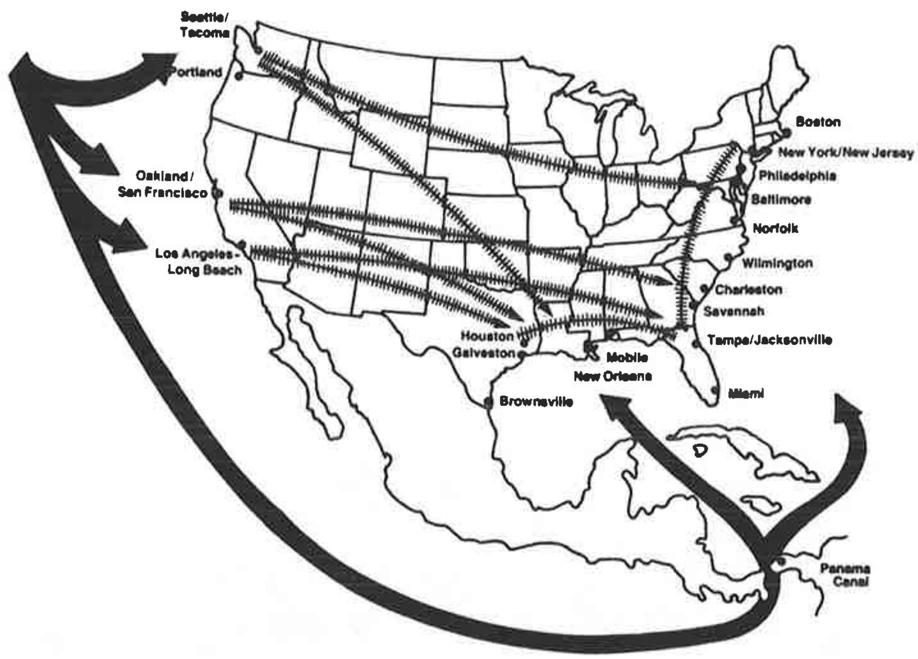


FIGURE 10 East and Gulf Coast via West Coast from Asia.

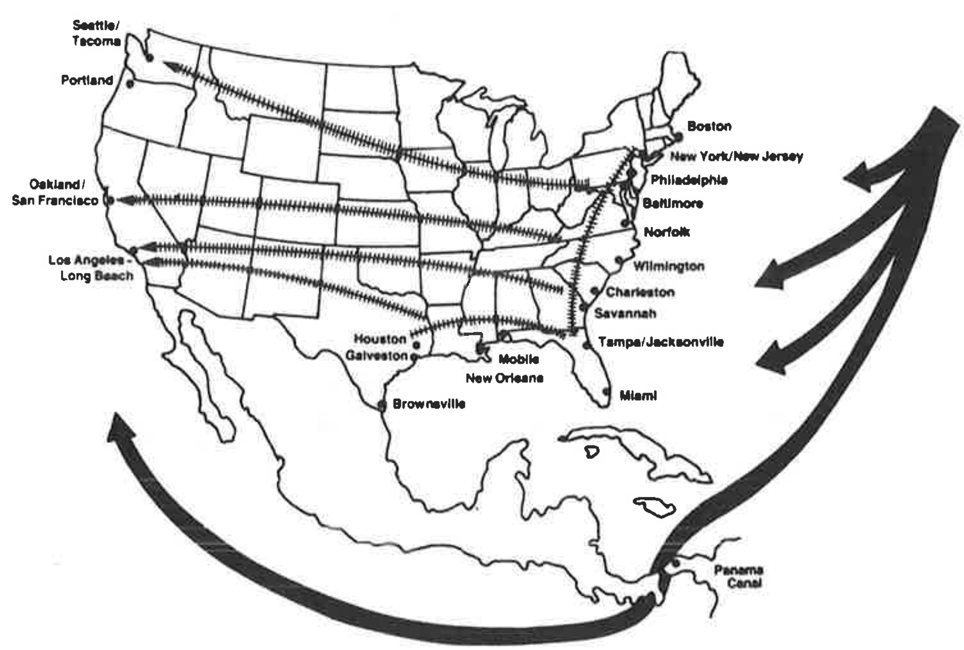


FIGURE 11 Europe to West Coast via East and Gulf Coast.

to ports on the U.S. Gulf and East coasts, as they have done traditionally, or they can be unloaded at a West Coast port and move by rail across the country to their final destination. Likewise, imports from Europe to the markets in the western United States can transit the canal or move by rail from an East Coast port.

As noted earlier, container traffic through the Panama Canal has continued to increase, and, with declining bulk traffic after 1982, containership percent of total volume has grown even faster from about 8 percent in the 1976–82 time period to about 15 percent in the 1986–87 time period (Figure 12) (*8*). Toll receipts from containerships have increased steadily during the 1980s and have accounted for more than 20 percent of Canal revenues since 1983 (Figure 13). However, the containership percent of total receipts has fallen slightly since 1985 as bulk traffic rebounded. Container movements to or from the United States dominate container tonnage through the canal, accounting for more than 70 percent (Figure 14). So emerging technologies such as rail minibridge, which could herald a shift in shipping patterns in the U.S. container trade, have important implications for the canal.

Growth of Minibridge Traffic

Further evidence of the growing importance of minibrige is the rapid increase in containerized imports at U.S. West Coast ports (Figure 15). U.S. Pacific ports increased their share of the nation's container trade from 31 to 46 percent between 1981 and 1987, and handled a little less than 75 percent of the Far East liner trade (*9*). Los Angeles and Long Beach dominate West Coast container traffic, having grown at an annual rate of nearly 20 percent from slightly more than 1 million TEUs in 1981 to more than 3 million TEUs in 1987 (or nearly 23 percent of the U.S. total). Seattle and Tacoma have experienced significant growth since 1984, with volume nearly doubling by 1987 to more than 1.7 million TEUs. The rapid growth in container throughput at the Puget Sound ports

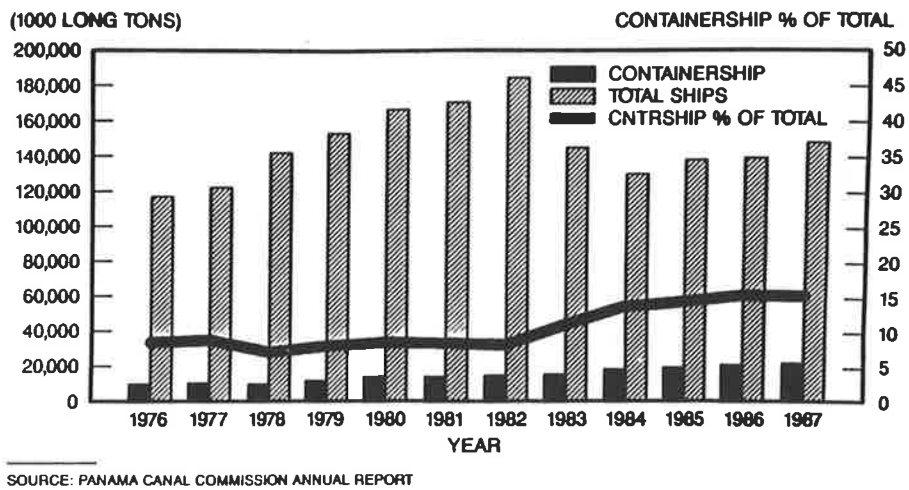


FIGURE 12 Panama Canal traffic, 1976–1987, total transits (in 1,000 long tons)

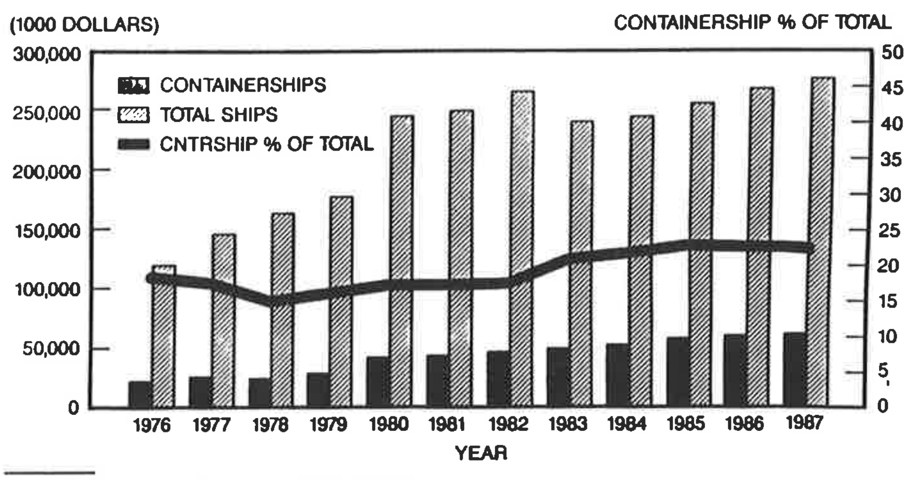


FIGURE 13 Panama Canal toll collection, 1976–1987 total transits (in $1,000).

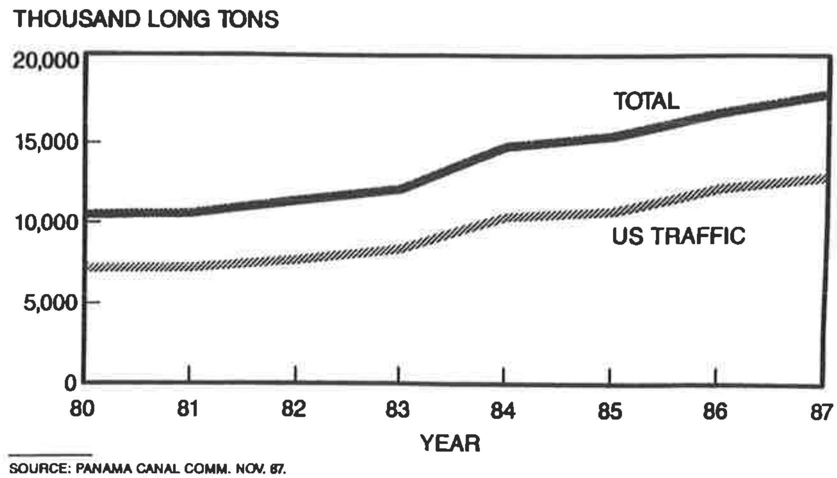


FIGURE 14 Container movements via Panama Canal: total and U.S. traffic.

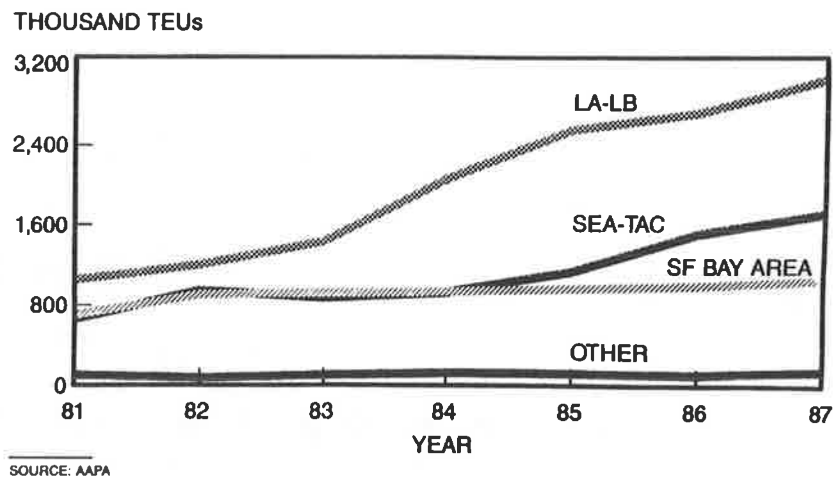


FIGURE 15 Growth in West Coast port container traffic, 1981–1987.

coincides with the introduction of dedicated double-stack rail service from this region to Chicago and the construction of added terminal facilities for this traffic.

An analysis of Census Bureau foreign trade data by the Port of Oakland estimated containerized imports to the U.S. East Coast based on liner traffic statistics (more than 90 percent are generally containerized) (*10*). The study found that minibridge rail traffic in Far East containerized imports bound for the U.S. East and Gulf Coast areas has been growing nearly every year since 1978 (Figure 16). Minibridge volume is estimated to have grown from less than 1.1 million tons in 1978 to 1.7 million tons by 1983 (an annual rate of 9 percent). The rate of growth then increased to more than 15 percent annually, and volume of traffic reached 3.0 million tons in 1987. Meanwhile, liner imports via the Panama Canal increased from 4.1 to 5.6 million tons between 1983 and 1987. The data indicate that minibridge captured a slowly increasing share of the East Coast market, growing from 29.7 percent in 1983 to 34.8 percent in 1987 (for an annual growth rate of about 4 percent).

The economics driving this increase in minibridge rail traffic are based on the savings associated with the use of double-stack container unit trains in dedicated scheduled service between West Coast ports and points in the Midwest and East. A double-stack container train can carry more than twice the cargo volume of a conventional piggyback service and do so with only a marginal increase in locomotive power and virtually no increase in labor (*11*). The potential efficiencies of double-stacks for both railroads and ocean carriers has led to a rapid increase in the number and routes of double-stack unit or mixed trains departing West Coast ports every week for interior and East Coast destinations. The number and destinations of stack trains has proliferated dramatically over the last several years, increasing from 22 per week in February 1986 to at least 76 by January 1988 (*12*, *13*). By August 1988, the number of departures was reportedly over 100 (*14*).

A principal factor driving the increase in rail minibridge traffic is the potential savings in time versus the all-water route (Figure 17). This savings in time can amount to 10 days or more from various Far East ports to New York (*15*). This can

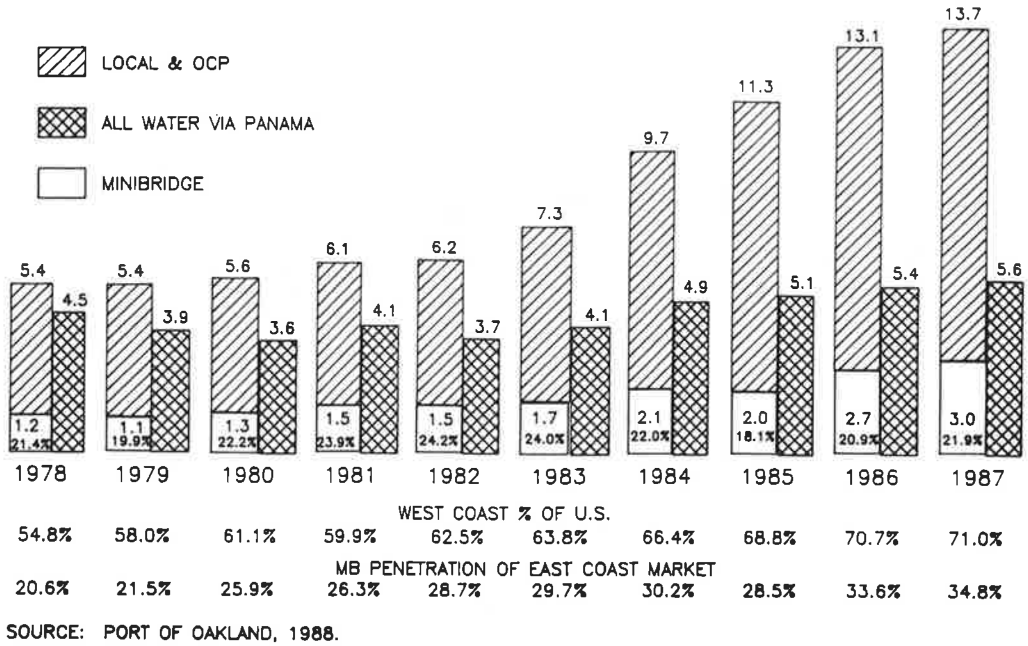


FIGURE 16 Far East and SEA liner imports to West and East Coast, 1978–1987 million short tons.

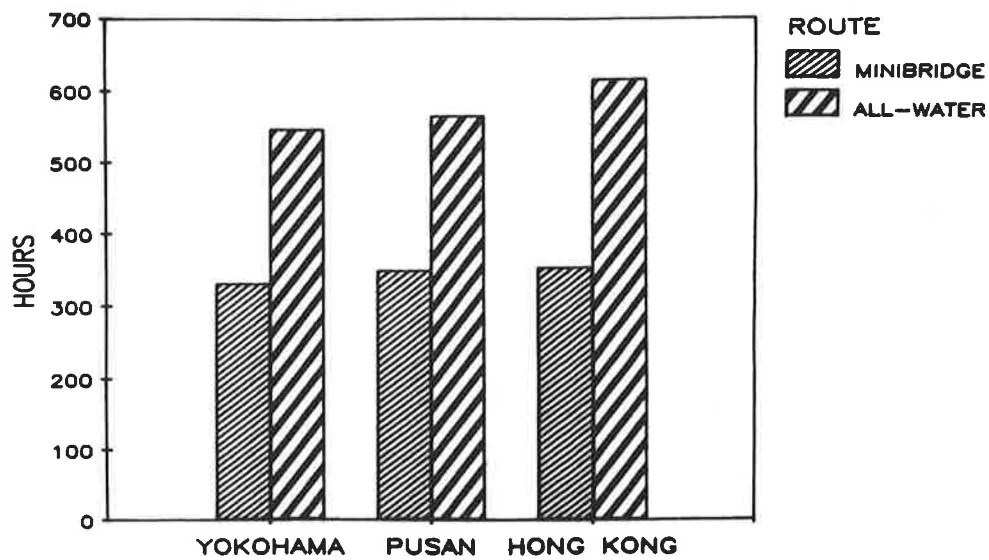


FIGURE 17 Average hours for container movement, selected Asian ports to New York: alternate routes via West Coast minibridge and via all-water through Panama Canal.

be especially desirable for high-value commodities. However, the minibridge cargo movement has to balance the higher cost per mile of the shorter rail movement across the United States with the lower cost per mile of the longer all-water route through the Panama Canal (*16*).

For certain destinations and time-sensitive commodities, the savings associated with double-stack unit trains can make the necessary difference to shift cargo from the all-water route (Figure 18). An analysis by Booz-Allen & Hamilton compared shipping costs from the Far East to U.S. East and Gulf Coast destinations by all-water, by single-stack container-on-flat-car (COFC) unit train from the West Coast, and by double-stack unit train from the West Coast (*17*). The analysis shows a range of costs depending on the Far East origin and makes some favorable assumptions about rail use. In general, however, the study found all-water to be cheaper to Savannah/Charleston and, depending on the origin port, to Baltimore, but only marginally so. Double-stack rail minibridge was cheaper to New York, Houston, and Chicago, and in all cases was cheaper than COFC unit trains. The high all-water costs

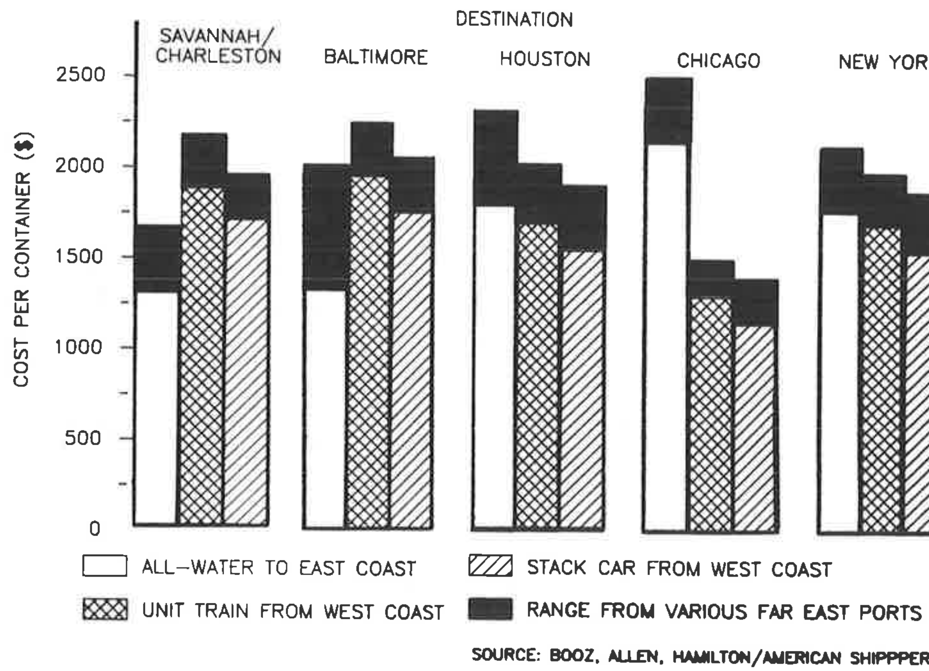


FIGURE 18 All-water versus bridge and stack car operating costs from Asia to selected destinations.

to Chicago are particularly striking and indicate the uncompetitive position of Great Lakes/Seaway ports in trading with the Far East.

For the bulk trades, minibridge rail is not a factor, but changing vessel sizes are. As noted earlier, coal traffic through the Panama Canal showed sizable increases up to 1982 and then dropped off dramatically. The early 1980s was a peak period for U.S. coal exports, totaling more than 112 million tons in 1981 (*18*). Importing nations in Europe and the Far East deepened their ports to handle increasingly larger coal colliers and urged exporting nations to do the same to take advantage of the much lower costs/ton for shipping. Australia and South Africa moved quickly to develop export terminals that could handle very large coal colliers. Canada also has deep draft coal export facilities in British Columbia. The United States, however, was unable to proceed with port-deepening plans until funding mechanisms were reconciled by passage of the Water Resources Development Act of 1986. Now the United States has been surpassed by Australia as the world's leading coal exporter and most forecasts do not project again achieving the level of coal exports of 1981 during the remainder of the century.

The following section presents a similar analysis of the development and traffic patterns of the St. Lawrence Seaway, and the forces of technological change that may be affecting its future and that of the Panama Canal.

ST. LAWRENCE SEAWAY

Earlier in this paper the what, when, where, why, and who of the Panama Canal and the St. Lawrence Seaway were discussed. In this section of the paper, the situation of the St. Lawrence Seaway and information on the world fleet that can transit the restrictive dimensions of the Panama Canal and the St. Lawrence Seaway are reviewed in more detail.

Purpose of the Seaway

The St. Lawrence Seaway was constructed mainly to serve inbound iron ore and outbound grain. The iron ore movement is from Labrador in Canada to steel mills along the U.S. shoreline of the Great Lakes. Iron ore movements are from Sept-Iles on the lower St. Lawrence (as shown in Figure 19) through the St. Lawrence, Lake Ontario, and the Welland Canal to steel centers such as Buffalo, Cleveland, Toledo, Detroit, and Chicago. The iron ore is also transshipped to the Pittsburgh area from locations such as Conneaut and Ashtabula on the shore of Lake Erie. The dominant outbound movement is grain exports from both the United States and Canada. The main grain export from Canada is wheat, whereas the U.S. exports are corn, soybeans, wheat, barley, rye, and other small grains. This movement of the grain downbound in lakers with a return haul upbound of iron ore is a very efficient move. The U.S. grain is unloaded for storage and transferred to ocean vessels at Montreal, Quebec, Baie Comeau, and other ports on the lower St. Lawrence. In addition to the iron ore-grain movement, grain is exported directly from the ports on the Great Lakes to overseas destinations via the Welland Canal and the St. Lawrence Seaway. Potential overseas general cargo is generated by the industrialized and highly populated Midwest of the United States, plus major Canadian cities. Overseas general cargo in the area of the United States that could be served by Great Lakes ports has been estimated at 15 to 25 percent of total U.S. overseas general cargo. However, only a small fraction of that trade moves directly overseas via the Great Lakes/St. Lawrence Seaway, partly because of the 9-month navigation season.

Profile of Great Lakes-St. Lawrence

Why the canals? The extreme topography that must be overcome in arriving at the most inland of the Great Lakes is

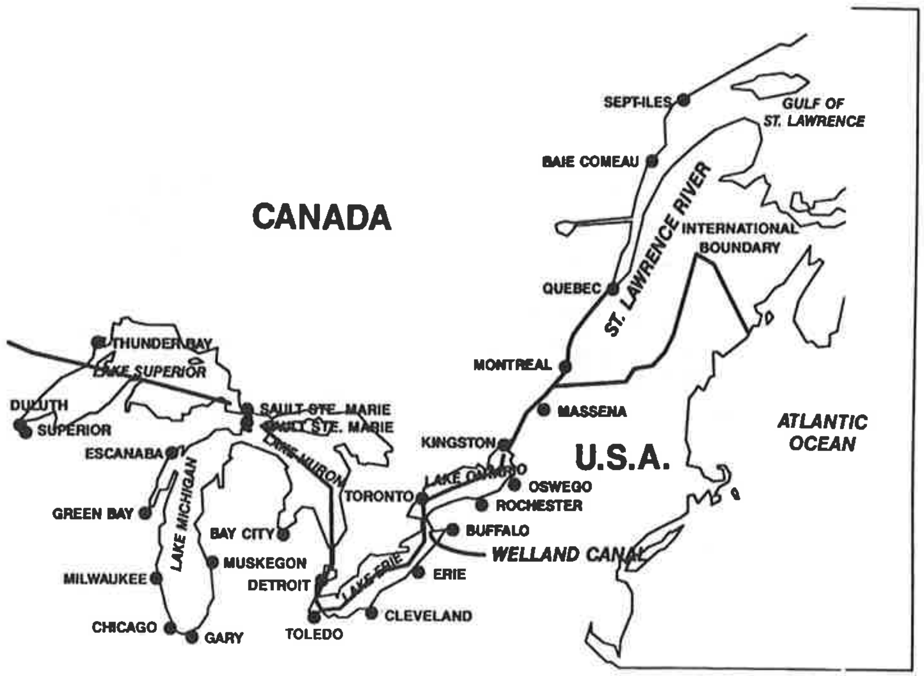


FIGURE 19 St. Lawrence Seaway system.

illustrated in Figure 20. The rise is about 20 ft from the Atlantic Ocean to Montreal at tidewater, which is about 1,000 miles from the sea. From Montreal, the St. Lawrence River has rapids and rises to 248 ft above sea level in Lake Ontario. The next climb, a very steep one in the vicinity of Niagara Falls, lifts the ships via the Welland Canal from 248 to 572 ft above sea level in Lake Erie. The navigation from Lake Erie to Lake Huron and Lake Michigan requires no canals. However, the next jump up to Lake Superior is about a 27-ft rise over the St. Mary's River Rapids, at Sault Ste. Marie, Michigan, and Ontario. This gives a total distance from the Atlantic Ocean to Duluth, Minnesota, at the head of the lakes, as 2,342 miles.

Traffic

The traffic on the St. Lawrence Seaway responded very rapidly from a low tonnage in 1958 with only a 14-ft channel to about 20 million tons in 1959 with the opening of the St. Lawrence Seaway with a 27-ft controlling depth. The traffic continued to increase until 1974, then fell during a recession but rebounded rapidly until it peaked in 1979 at about 74 million tons (Figure 21). The traffic has declined since that time, with peaks and valleys to the current traffic of about 50 million tons in 1987 (*19*). Preliminary estimates for 1988 are an increase of one to two percent (conversation with Robert J. Lewis, Seaway Development Corporation, Washington,

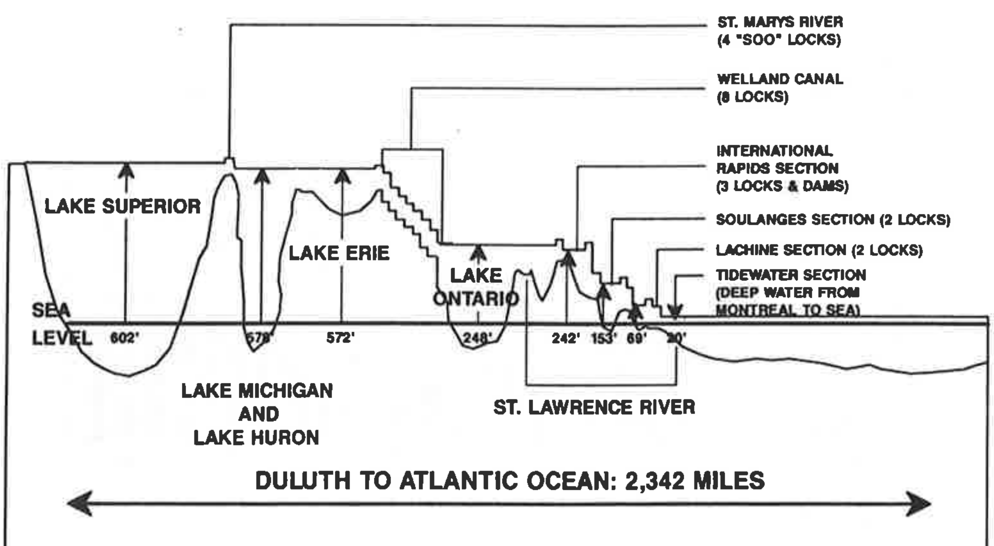


FIGURE 20 St. Lawrence Seaway system profile.

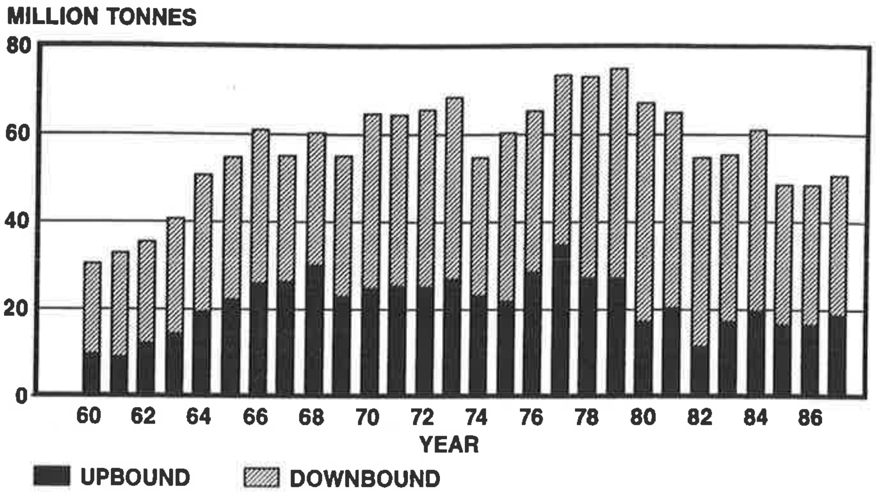


FIGURE 21 St. Lawrence Seaway traffic cargo tonnes (million).

D.C.) The pattern of upbound and downbound traffic shows the upbound traffic peaking in 1977 because of the iron ore movement. It has been on a decline since that time, with some reversal in 1987. The downbound movement has been greater than the upbound movement in most periods, such as 1987 when about 32 million tons moved downbound, whereas only 18 million tons moved upbound.

The revenue received from tolls for 1959 to 1987 is shown in Figure 22 (*20*). This shows a pattern similar to traffic with increases until 1974. Tolls then drop off, followed by a substantial rise in the late 1970s. Presently, tolls are near the 1984 peak, when toll revenue reached $71 million.

Major Commodities and Industrial Types

The composition of the traffic on the St. Lawrence Seaway, on the Montreal to Lake Ontario section is as follows (*20*). The major commodities are Canadian grains at 32 percent, iron ore at 25 percent, U.S. grains at 13 percent, iron and steel at 10 percent, miscellaneous minerals at 10 percent, miscellaneous manufactures at 5 percent, and chemicals and petroleum products at 5 percent. Adding the two grains together, indicates that about 45 percent of the traffic is composed of grains and that is dominantly for export overseas. It is clear that grains combined with iron ore make up about 70 percent of total seaway commerce. The iron and steel is dominantly imported steel; however, there have been some exported iron and steel. The miscellaneous manufactures and the iron and steel that are included among oceangoing general cargo commodities account for only 15 percent of seaway traffic.

Vessels carrying the cargo in 1987 included the laker, which is dominant in the movement of iron ore upbound and grain downbound to the lower St. Lawrence ports. It accounted for 64 percent of the cargo moved and carried 25 million tons (*20*). Ocean ships carried 15 million tons and accounted for 36 percent of the cargo (grain exports as well as general cargo).

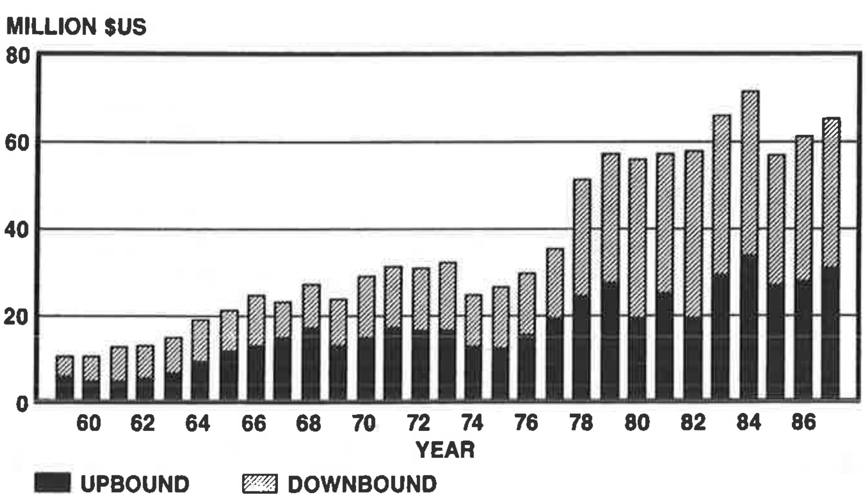


FIGURE 22 St. Lawrence Seaway traffic revenues ($ U.S. million): 1959–1987.

U.S. Areas Served by the St. Lawrence Seaway

Before the opening of the 27-ft St. Lawrence Seaway in 1959, most U.S. Great Lakes ports sought deepening to serve the vessels that would transit the St. Lawrence Seaway. The Corps of Engineers of the North Central Division undertook extensive studies of general cargo (*20*) and grain (*21*) to estimate the future traffic for the Great Lakes ports that were seeking improvement—largely deepening—with federal funds. Most of the Great Lakes ports were in the range of 18- to 23-ft-deep channels. The ocean ports, that is the Atlantic, the Gulf, and the Pacific ports, were all concerned about the competition that would be offered to them by the St. Lawrence Seaway. It is well known that the Midwest was a great generator and consumer of manufactured goods and producer of agricultural commodities. To obtain data necessary for the transportation analyses, an origin and destination study was conducted under agreement with the U.S. Bureau of the Census (*22*). A transportation cost analysis, based on land and ocean carrier costs and least-cost routing models, produced the areas tributary to the Great Lakes ports shown in Figure 23 for overseas general cargo traffic (*20*). As expected, the most extensive tributary area was for Europe, especially northern Europe, which is a great circle route from the Gulf of St. Lawrence. The least extensive tributary area was for the Far East with a routing via the Panama Canal. A parallel study was conducted for grain exports. The result of that transportation cost analysis is shown in Figure 24 (*21*), which depicts the tributary area for wheat exports to Rotterdam. That tributary area is shown extending as far as Montana on the north and into Nebraska and parts of Missouri and central Illinois, central Indiana, and central Ohio to the south. The major differences compared with the general cargo tributary area is that the Minneapolis/St. Paul area is shown being on

FIGURE 23 Areas tributary to the Great Lakes-St. Lawrence Seaway.

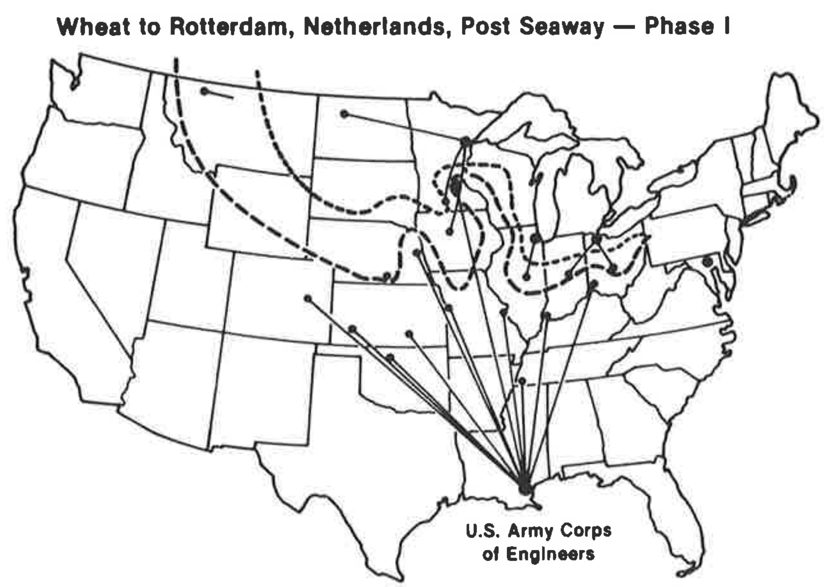


FIGURE 24 Contours of transportation cost advantage for exports via Great Lakes-St. Lawrence Seaway.

the border of the tributary area for grain. This is based on the low-cost barge movements down the Mississippi River from Minneapolis/St. Paul to export in the Gulf. This feature shows that grain traffic from Minneapolis/St. Paul could move either by the Great Lakes or New Orleans for about the same transportation cost. These cost relationships to depict the tributary areas are shown in Figures 23 and 24 and labeled "Phase I," which represented an equilibrium for 1959 continuing to the early or mid 1970s.

Projected and Historical Traffic

The studies conducted produced the projections of imports and exports of general cargo and exports of grain as shown in Figure 25 (*23*). When the studies were made before the St. Lawrence Seaway was built, the existing traffic was 0.6 million tons. In the first year of the seaway, the traffic was about 5 million tons. It continued to increase, as shown by the solid line, to about 12 million tons in 1970, and then, amid peaks and valleys, hit almost 20 million tons in the late 1970s. Traffic then declined to about 8 million tons in the early 1980s and currently is around 10 to 12 million tons. The projected traffic is shown by the dashed line and is very similar to the actual traffic up to the period of the early 1970s, when actual traffic began to experience wide fluctuations. This disparity between the historical traffic and the projected traffic is largely the result of technological changes, which will be discussed in the following sections.

Impact of Technological Changes

The largest volume of traffic on the St. Lawrence Seaway is grain, both Canadian and U.S., which accounts for about 45

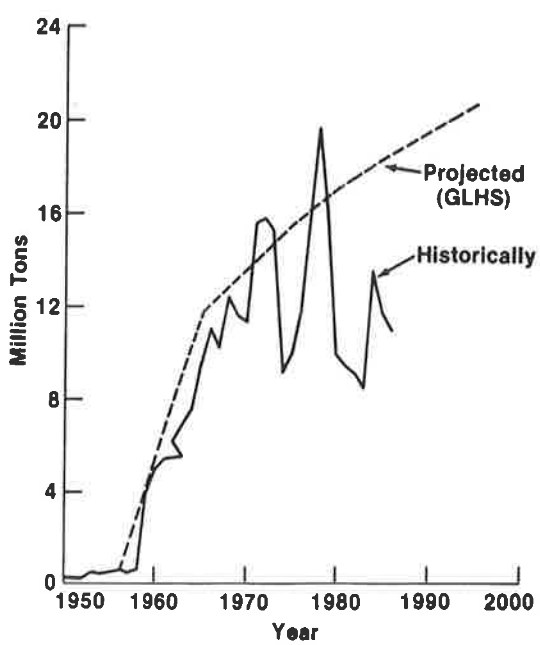


FIGURE 25 U.S. Great Lakes-overseas: direct waterborne commerce.

percent of the traffic. In the late 1970s and the early 1980s, the United States dominated that grain movement with up to two-thirds of the world's total. Presently, that number is more like 50 percent. Why? The green revolution in many countries resulted in a great increase in production in countries competing with the United States. This green revolution witnessed technological developments in seed, fertilizer, and agricultural practices. Advances in barge efficiency have produced a heavy flow down the Mississippi River for export from New Orleans and other Gulf ports. The development of the 100-ton hopper rail car and the unit train has also provided substantial competition to the Seaway. These efficient movements by rail for grain movements to east and west coast ports have brought further competition for the Seaway. The grain movement on the Mississippi starts at Minneapolis/St. Paul, which is right in the backyard of the Great Lakes. Grain movement to Great Lakes and Seaway ports is dominantly carried out by shorthaul overland movement by truck (*24*). The development of larger ocean vessels that call at ocean ports that have been or are being deepened provides further stiff competition to the Seaway, with its fixed dimensions. The shift by western Europe from major importer to exporter of grain has changed U.S. export markets to areas less favorable to the St. Lawrence Seaway route. The U.S. Great Lakes ports' percentage of the nation's grain exports has declined over the years from a high of about 15 to 20 percent in the early years of the Seaway to around 10 percent of the U.S. waterborne grain exports currently moved by the Seaway.

For general cargo, the technological advances in transportation have been in the field of containerization, which has brought very stiff competition to the Great Lakes. All time-sensitive shipments, which may be of high value, are candidates for the ports that can provide highly frequent service and are able to accommodate large containerships that cannot transit the Great Lakes/St. Lawrence Seaway. Development of the double-stack container car and train has brought even more efficiency to the inland movements serving ocean ports. Chicago has become the major center for a transfer of double-stack trains from east and west coast origins and destinations. Containers are distributed from Chicago by either train or truck. The port of Milwaukee recently announced double-stack train service resulting from rail movement of double-stack cars from Montreal as the deep-water port.

Technological Changes and Transportation Costs

Technological changes in transportation have resulted in lower costs to the shipper, as noted in Figure 26 (*25*). The 4,200-TEU containership has a cost of about 0.3 cent/ton-mile compared with 1 cent/ton-mile for the 1,800-TEU containership. This compares with the conventional freighter of about 4 cents/ton-mile. This difference has a decided impact on movement of traffic through the Panama Canal, which cannot accommodate the 4,200-ton ship, or through the St. Lawrence Seaway, which largely accommodates the conventional freighter. For rail movement, the double-stack express train is shown as about 3 cents/ton-mile, compared with the conventional rail which ranges from about 4 to about 15 cents/ton-mile or an average of about 8 cents/ton-mile. For further cost comparisons, the relative shipper cost index for a variety of over-

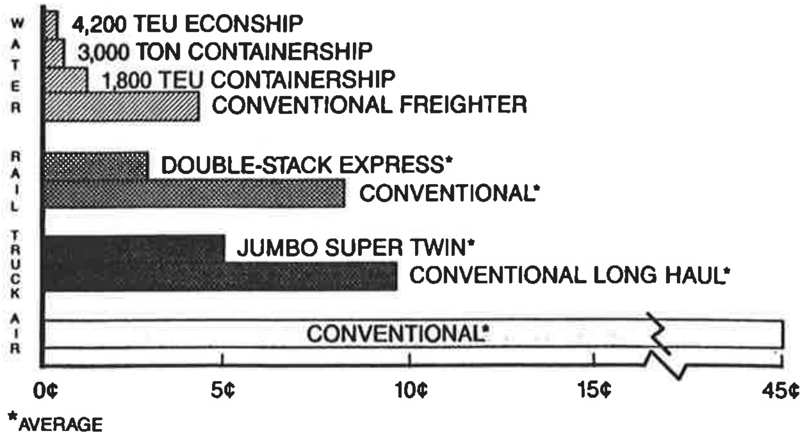


FIGURE 26 Cost per ton mile.

land movements is shown in Figure 27. Using truck as an index of 100, the twin trucks are shown at 65, the box car at 80, the trailer and flat car at 75, and the container on a flat car at 65. The double stack, however, is 40. This 40 index represents about a 38 percent saving over the conventional COFC or the truck twin 45s.

Another factor in the movement of foreign trade is that of port costs. The cost for New York is $36/ton for handling containers, whereas for Boston and Baltimore it is $31. For U.S. west coast ports it is $25. This cost differential helps the economy of the minibridge movements from the U.S. west coast ports. The port of New York has recently announced a substantial rebate for container traffic that originates or terminates in a 250-mi radius.

Another aspect of transportation costs is that of the balance of movement. The imports of merchandise from Asia have been the dominant move in recent years, although there has been some recent improvement in the export picture. The U.S. merchandise trade balance for March 1988 is shown in Figure 28. This indicates that on the plus side, the first bar is the agricultural commodities, which are to the right, or a favorable plus balance of trade. The long bar indicates manufactured goods, the dominant move in containers. Other major commodities not containerized are petroleum and products, and bituminous coal, which is a plus but is a bulk commodity without backhaul potential. To rectify the situation, the major U.S. and foreign lines have developed a pattern in which they handle containerized domestic cargo as a backhaul that moves from eastern and Midwest points to U.S. west coast ports. This gives a balance of movement and hence reduces the overall cost.

World Fleet Able to Transit the Panama Canal and the St. Lawrence Seaway

To attempt to determine the world fleet able to transit the Panama Canal and the St. Lawrence Seaway, computer runs of Mardata were made based on (a) the length and beam limitations discussed earlier in this paper and (b) length, beam, and draft limitations, assuming that the ship was loaded to capacity. Data were developed for major types of vessels: containerships, general cargo, roll-on, roll-off, (RO-RO) vessels, dry bulk carriers and tankers, and these are shown in Table 1. The results for the Panama Canal are shown in Figure 29. Based on the number of ships in the world fleet and the limitation of length and beam, approximately 80 percent of the world's fleet could transit the Panama Canal. But if the

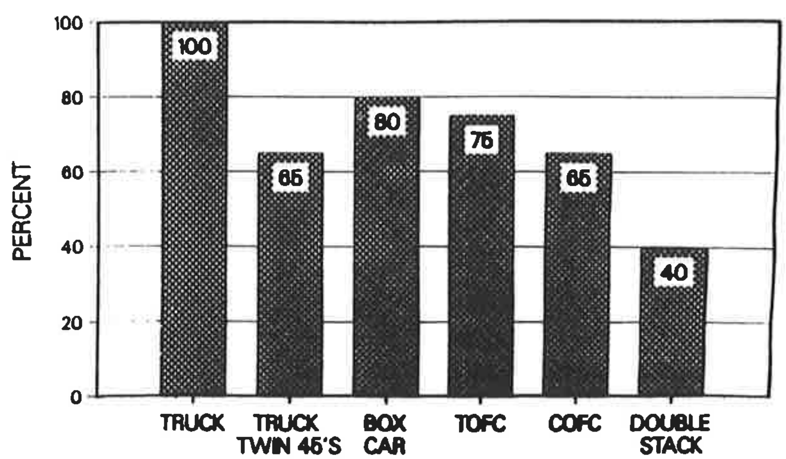


FIGURE 27 Relative shipper cost index.

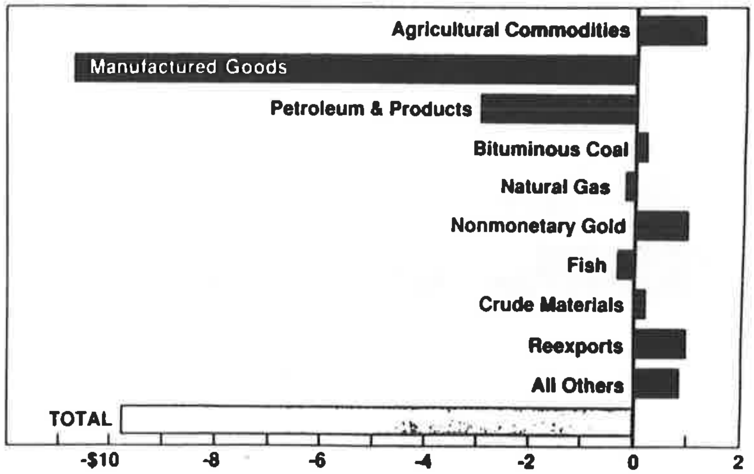


FIGURE 28 U.S. merchandise trade balance by category for March 1988 (in $ billion)

TABLE 1 PERCENT OF WORLD FLEET ABLE TO TRANSIT PANAMA CANAL AND ST. LAWRENCE SEAWAY

	Existing Vessels		Vessels On-Order	
Panama Canal				
	Vessel Maximum Dimensions (Feet)			
Length	950	950	950	950
Beam	106	106	106	106
Draft, 15 ft to	no limit	40	no limit	40
	Percent of World Fleet Based on Number of Ships			
Dry Cargo Vessels[2]	84	81	61	54
Dry Cargo Vessels and Tankers	80	76	53	47
	Percent of World Fleet Based on Deadweight Tons			
Dry Cargo Vessels[2]	73	60	40	26
Dry Cargo Vessels and Tankers	50	41	27	17
St. Lawrence Seaway				
	Vessel Maximum Dimensions (Feet)			
Length	730	730	730	730
Beam	76	76	76	76
Draft, 15 ft to	No Limit	26	No Limit	26
	Percent of World Fleet Based on Number of Ships			
Dry Cargo Vessels[2]	63	37	35	21
Dry Cargo Vessels and Tankers	57	35	28	17
	Percent of World Fleet Based on Deadweight Tons			
Dry Cargo Vessels[2]	33	10	11	4
Dry Cargo Vessels and Tankers	20	7	6	2

Source: Mardata and computer compilations by U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources, Jan 1989.

(1)Based on stated maximum dimensions for existing and on-order vessels.

(2)Containerships, general cargo vessels, RO-RO vessels and dry bulk carriers.

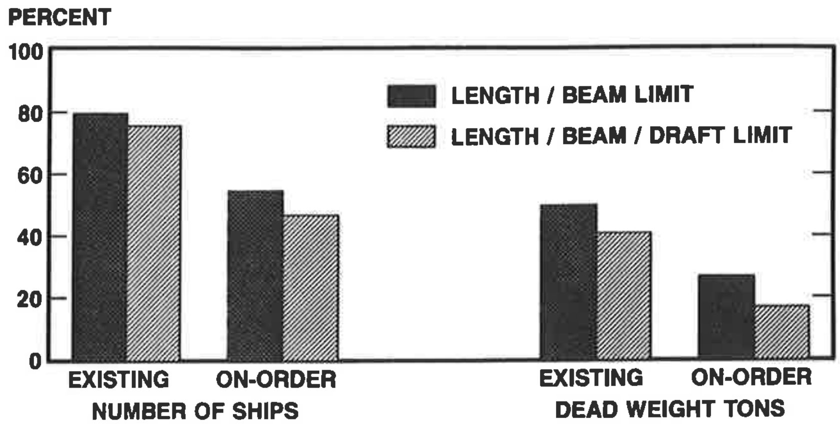


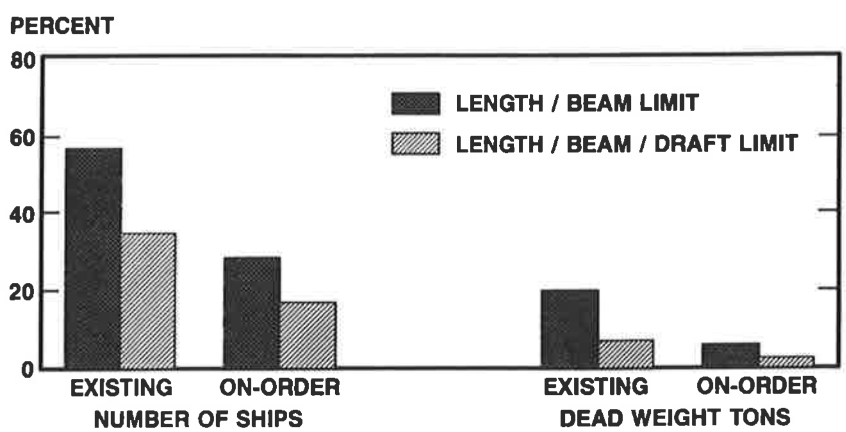
FIGURE 29 Percent of world fleet able to transit Panama Canal: existing and on-order for major vessel types.

limitation of draft is added, assuming fully loaded ships, that 80 percent reduces to about 76 percent. However, looking at future ships on order for the next 5 years, this figure drops to 53 percent of the world's ships, based on length and beam, or about 47 percent if the draft limitation is added. Based on deadweight tonnage, as shown in the right-hand-side of Figure 29 of the existing ships, only 50 percent would be able to navigate the Panama Canal based on length and beam, and only 41 percent with draft limitation. For ships on order, this drops to 27 percent of the ships based on length and beam limitation and 17 percent based on addition of the draft limitation. The percentages are all a bit higher if only dry cargo vessels are included in the analysis, as noted in Table 2.

The data for the St. Lawrence Seaway are shown in Figure 30. Based on the number of ships in the existing world fleet and on length and beam limitation, 57 percent of the world fleet could transit the St. Lawrence Seaway. However, if the limitation of the draft is added for fully loaded ships, this decreases to 35 percent of the world fleet that can transit the St. Lawrence Seaway. For ships on order, based on number of ships, only 28 percent of those would be able to transit the Seaway based on length and beam and a further drop to 17 percent is noted if a draft limitation for fully loaded ships is added. Based on deadweight, even lower percentages are noted as follows. Based on beam and length limitations, only 20 percent of the ships can transit the Seaway, and only 7 percent of the world fleet if the draft limitation is added. For ships on order and based on the deadweight category, only 6 percent of the world's fleet could transit the seaway based on beam and length limitations, and only 2 percent if the draft limitation is included. A slightly higher percentage of the world fleet that can transit the Seaway based on dry cargo vessels only is shown in Table 2. The impact of the increasing size of vessels and the problem of the fixed dimensions of canals limiting the fleet that can transit those canals is obvious.

SUMMARY

The following briefly summarizes the major factors previously noted: the ship size, the containerization, and the minibridge, which includes the double-stack. Affecting the Panama Canal is the pipeline moving crude petroleum from the Pacific to the Atlantic. For the St. Lawrence Seaway, the technological



Source: MARDATA NETWORK.

FIGURE 30 Percent of world fleet able to transit St. Lawrence Seaway: existing and on-order for major vessel types.

changes in the steel industry, including taconite, have had a profound effect. Agricultural development abroad and the green revolution have severely affected grain exports. An additional factor, although not necessarily technological, is deregulation, which, along with the unit train and 100-ton car, has had a great impact on the St. Lawrence Seaway. In summary, technological changes have produced more efficient transportation and have shaken the existing transportation routings to create entirely new patterns of commodity movements.

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